CLAIMS

What is claimed is:

1. A method for forming a copper damascene comprising the steps of:

providing a substrate comprising a semiconductor substrate;

forming an insulator layer on the substrate;

forming a damascene opening through a thickness portion of the insulator layer;

forming a diffusion barrier layer to line the damascene opening;

forming a first seed layer overlying the diffusion barrier;

plasma treating the first seed layer in-situ with a first treatment plasma comprising plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;

forming a second seed layer overlying the first seed layer;

forming a copper layer overlying the second seed layer according to an electro-chemical plating (ECP) process to fill the damascene opening; and,

planarizing the copper layer to form a metal interconnect structure.

2. The method of claim 1, wherein at least one of the first and second seed layers forms a continuous layer over active areas of the substrate.

3. The method of claim 1, wherein at least the second seed layer forms a continuous layer over active areas of the substrate.

4. The method of claim 1, wherein one of the first and second seed layers is substantially nonconformally deposited.

5. The method of claim 1, wherein one of the first and second seed layers is substantially conformally deposited.

6. The method of claim 1, wherein the first seed layer is deposited according to a deposition process selected from the group consisting of CVD, IMP, SIP, and electroless.

7. The method of claim 6, wherein the second seed layer is deposited according to a PVD process.

8. The method of claim 1, wherein the first seed layer is deposited according to a PVD process.

9. The method of claim 8, wherein the second seed layer is deposited according to a deposition process selected from the group consisting of CVD, IMP, SIP, and electroless.

10. The method of claim 1, further comprising the step of plasma treating the second seed layer with a second treatment plasma formed of plasma source gases selected from the group consisting of argon, nitrogen, and hydrogen prior to the step of forming the copper layer.

11. The method of claim 1, wherein the plasma source gases consist essentially of plasma source gases selected from the group consisting of argon (Ar), nitrogen (N_2), hydrogen (H_2), ammonia (NH_3), and a nitrogen/hydrogen (N_2/H_2) mixture.

12. The method of claim 1, wherein the first and second seed layers comprise a material selected from the group consisting of Cu, Ti, TiN, Ta, TaN, Cr, CrN, W, and WN.

13. The method of claim 1, wherein at least one of the first and second seed layers is formed of copper or alloy thereof.

14. The method of claim 1, wherein the insulator layer comprises a low-K dielectric insulator having a dielectric constant of less than about 3.0.

15. The method of claim 1, wherein the first seed layer is formed having a thickness of about 50 Angstroms to about 300 Angstroms.

16. The method of claim 1, wherein the second seed layer is formed having a thickness of about 100 Angstroms to about 400 Angstroms.

17. The method of claim 1, wherein the diffusion barrier layer comprises a material selected from the group consisting of Ti, TiN, Ta, TaN, Cr, CrN, W, and WN.

18. A method for forming a copper damascene comprising the steps of:

providing a substrate comprising a semiconductor substrate and metal interconnect structures;

forming a low-K dielectric insulator layer on the substrate;

forming a damascene opening through a thickness portion of the low-K dielectric insulator layer;

forming a diffusion barrier layer to line the damascene opening;

forming a first seed layer over the diffusion barrier layer;

plasma treating the first seed layer with a first treatment plasma comprising plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;

forming a second seed layer over the first seed layer;

plasma treating the second seed layer with a second treatment plasma comprising plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;

forming a copper layer over the second seed layer according to an electro-chemical plating (ECP) process to fill the damascene opening; and,

planarizing the copper layer to form a metal interconnect structure.

19. The method of claim 18, wherein the first seed layer is deposited according to a deposition process selected from the group consisting of CVD, IMP, SIP, and electroless.

20. The method of claim 19, wherein the second seed layer is deposited according to a PVD process.

21. The method of claim 18, wherein the first seed layer is deposited according to a PVD process.

22. The method of claim 21, wherein the second seed layer is deposited according to a deposition process selected from the group consisting of CVD, IMP, SIP, and electroless.

23. The method of claim 18, wherein the plasma source gases consist essentially of plasma source gases selected from the group consisting of argon (Ar), nitrogen (N_2), hydrogen (H_2), ammonia (NH_3), and a nitrogen/hydrogen (N_2/H_2) mixture.

24. The method of claim 18, wherein the first and second seed layers comprise a material selected from the group consisting of Cu, Ti, TiN, Ta, TaN, Cr, CrN, W, and WN.

25. The method of claim 18, wherein at least one of the first and second seed layers is formed of copper or alloy thereof.

26. The method of claim 18, wherein the low-K dielectric comprises a dielectric constant of less than about 3.0.

27. The method of claim 18, wherein the first seed layer is formed having a thickness of about 50 Angstroms to about 300 Angstroms.

28. The method of claim 18, wherein the second seed layer is formed having a thickness of about 100 Angstroms to about 400 Angstroms.

29. The method of claim 18, wherein the diffusion barrier layer comprises a material selected from the group consisting of Ti, TiN, Ta, TaN, Cr, CrN, W, and WN.

30. A copper filled damascene comprising:

a substrate comprising a semiconductor substrate and metal interconnect structures;

an insulator layer on the substrate;

a damascene opening extending through a thickness portion of the insulator layer;

a diffusion barrier layer to lining the damascene opening;

a first seed layer overlying the diffusion barrier comprising a substantially oxide-free plasma treated surface;

a second seed layer overlying the first seed layer; and,

an ECP copper layer overlying the second seed layer filling the damascene opening.

31. The copper filled damascene of claim 30, wherein at least one of the first and second seed layers forms a continuous layer over active areas of the substrate.

32. The copper filled damascene of claim 30, wherein at least the second seed layer forms a continuous layer active areas of the substrate.

33. The copper filled damascene of claim 30, wherein one of the first and second seed layers is a substantially nonconformal layer.

34. The copper filled damascene of claim 30, wherein one of the first and second seed layers is a substantially conformal layer.

35. The copper filled damascene of claim 30, wherein the second seed layer comprises a substantially oxide-free plasma treated surface.

36. The copper filled damascene of claim 30, wherein the first and second seed layers comprise a material selected from the group consisting of Cu, Ti, TiN, Ta, TaN, Cr, CrN, W, and WN.

37. The copper filled damascene of claim 30, wherein at least one of the first and second seed layers is formed of copper or alloy thereof.

38. The copper filled damascene of claim 30, wherein the insulator layer comprises a low-K dielectric insulator having a dielectric constant of less than about 3.0.

39. The copper filled damascene of claim 30, wherein the first seed layer is formed having a thickness of about 50 Angstroms to about 300 Angstroms.

40. The copper filled damascene of claim 30, wherein the second seed layer is formed having a thickness of about 100 Angstroms to about 400 Angstroms.

41. The copper filled damascene of claim 30, wherein the diffusion barrier layer comprises a material selected from the group consisting of Ti, TiN, Ta, TaN, Cr, CrN, W, and WN.